An Environmental Study of the Passaic River and its Estuary[†]

L. Anthony Wolfskill, PhD., P.E. [*]
Richard P. McNutt [**]

INTRODUCTION

The Diamond Alkali Project Team (Project Team), comprised of representatives of former operators and owners of the Diamond Alkali facility at 80 Lister Avenue in Newark, New Jersey, voluntarily initiated an environmental study of Newark Bay in 1990. The study centers on the Newark Bay and its tributaries (Estuary), with a particular emphasis on the lower Passaic River (River), and continues under the oversight of the United States Environmental Protection Agency (EPA). The study has fostered an improved understanding of sediment and water quality and has provided additional data on

[†] Editor's note: The symposium that gave rise to this article occurred on March 30, 1998. At that time, the United States Environmental Protection Agency (EPA) was still considering how the dioxin contamination at the Diamond Alkali Superfund Site would be remedied. Prior to the publication of this journal, however, the EPA gave final approval to a 1990 consent decree, which permits the on-site burial of dioxin waste at the Diamond Alkali site. *See* Tom Johnson, *Dioxin Site in Newark to be Sealed Underground*, STAR-LEDGER (Newark), Aug. 5, 1998, at 15.

[*] Dr. L. Anthony Wolfskill is a Professional Engineer, specializing for the past 19 years in the remediation and restoration of contaminated upland, sediment, riverine, and estuarine sites. Prior to this period, he practiced in the civil engineering and geotechnical capital projects field including an appointment to the faculty and research staff at M.I.T. in Cambridge, Massachusetts. Dr. Wolfskill has worked extensively on over one hundred environmental sites in 21 states, Venezuela, and Czechoslavakia. He has worked on several sites in New Jersey, including the Diamond Alkali Superfund Site since 1983. His work included all of the phases of environmental projects, from negotiation of orders through the science, engineering, remedial construction, and long-term post-remediation care activities. Dr. Wolfskill holds degrees from Texas A&M University (B.S., M.S., Ph.D.) and Harvard University (S.M.).

[**] Richard P. McNutt is a project manager for Chemical Land Holdings, Inc. He has managed numerous environmental projects and has worked on the Diamond Alkali Superfund Site since 1992. His work covers all phases of environmental projects including science, engineering, and remedial construction. Mr. McNutt holds degrees from Grove City College (B.A.) and the University of Pittsburgh (M.B.A.).

the historical degradation of the ecological habitat in the Estuary. To date, the Project Team has spent more than twenty-three million dollars on the scientific and engineering aspects of this study.

The scope of the work that the Project Team has completed so far is substantial. The Project Team collected and chemically analyzed numerous sediment samples from the Estuary. The study covered an area ranging from twenty-three miles north of Newark Bay in the Passaic River, along the Hackensack River, and south to the Arthur Kill, Elizabeth River, and Kill Van Kull.[1] The Project Team collected surface water quality samples from outfalls to the Passaic River. Additionally, the Project Team collected and analyzed more than 700 samples of surface and buried sediment in the Passaic River for chemicals. In other parts of the Estuary, environmental consultants collected and analyzed 230 additional sediment samples. D.W. Crawford published research on the ecological conditions in the Estuary over the past century.[2] Also, in 1994, environmental consultants conducted a detailed field survey to evaluate the current aquatic and terrestrial habitats within the lower Passaic River.[3] Research into the nature and locations of historical and current sources of chemical discharges to the Estuary, and particularly to the lower Passaic River, has also been conducted. All of this data has been provided to the EPA to support application of the various laws and regulations, and peer-review journals have published a large number of professional papers that interpret the data. Some representative topics of these manuscripts include the distribution of various contaminants such as mercury, lead, polychlorinated biphenyls (PCBs), dioxins, and polycylic aromatic hydrocarbons (PAHs) in the Newark Bay Estuary.[4] Currently, the EPA is overseeing a Remedial Investigation and Feasibility Study for the lower six miles of the Passaic River.

Summarized below are some of the findings of this comprehensive study that illustrate some technical and factual considerations for three legal issues implicated by environmental conditions in the River and Estuary. These legal issues are:

1. Baseline and Background Conditions
2. Damages

[1] *See infra* fig.1 for locations of these five tributaries to the Newark Bay.

[2] *See* D.W. Crawford et al., *Historical Changes in the Ecological Health of the Newark Bay Estuary, New Jersey*, 29 ECOTOXICOLOGY & ENVTL. SAFETY 276 (1994).

[3] *See* ChemRisk, McLaren/Hart Envtl. Eng'g, Screening-Level Human Health and Ecological Risk Assessment for the Passaic River Study Area, app.E, vol. II-B (July 6, 1995) (unpublished report, on file with ChemRisk).

[4] *See infra* app.A.

3. Sources of Chemicals and Causation

These terms are derived from the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA),[5] the National Contingency Plan (NCP),[6] and the Oil Pollution Act of 1990 (OPA).[7] Additionally, these terms are construed by various regulations that implement the natural resource damage provisions of CERCLA[8] and OPA,[9] as interpreted by numerous policy memoranda and guidance documents.[10] For purposes of clarity, this essay will employ simple and limited descriptions of these terms.

BASELINE AND BACKGROUND CONDITIONS

An objective in assessing damages for injury, destruction, or loss of natural resources is the restoration or replacement of such resources to their "baseline" condition — that condition which would have existed were it not for the particular release. Under CERCLA, the comparable term is "background" — the condition of the affected environmental media prior to the particular release. The background measurement forms the basis to determine the excess risk caused by such release.

Technical interpretations of factual site data are necessary to the determination of baseline or background conditions. Performing these technical interpretations becomes exceedingly daunting if the "conditions" that need to be characterized are obscured by many discharges from other sources, over differing time periods, resulting in a commingled chemical mix within the affected resources/environmental media. The contamination in the lower Passaic River and the Estuary is exactly such a chemical mix.

The historical development and industrialization of much of the Newark Bay Estuary, particularly along the lower Passaic River, has severely reduced the wetlands and ecological habitat. Along the lower six miles of the Passaic River, at least ninety percent of the original wetlands habitat no longer exists, replaced instead by land-

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[5] 42 U.S.C. §§ 9601-9675 (1994).

[6] 40 C.F.R. § 300 (1997).

[7] 33 U.S.C. §§ 2701-2761 (1993).

[8] 40 C.F.R. §§ 300.600-.615 (1997).

[9] 15 C.F.R. §§ 990.10-.66 (1997).

[10] *See, e.g.*, DAMAGE ASSESSMENT CTR., NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, GUIDANCE DOCUMENTS FOR NATURAL RESOURCES DAMAGE ASSESSMENT UNDER THE OIL POLLUTION ACT OF 1990: PREASSESSMENT PHASE, INJURY ASSESSMENT, SPECIFICATIONS FOR USE OF NRDAM/CME VERSION 2.4 TO GENERATE COMPENSATION FORMULAS, PRIMARY RESTORATION, RESTORATION PLANNING (1996).

fill, bulkheads, and shoreline riprap. Newark Bay and its southern tributaries have suffered a similar fate.

Figure 2 compares the alterations in the wetlands and habitat in Newark Bay and the lower Passaic River over time.[11] Prior to 1900, a large area of wetlands existed along the west bank of the Bay and both banks of the River as shown in the figure. By 1966, nearly all of the wetlands had been filled and the shipping channels of Port Newark had been constructed. By 1989, essentially all of the wetlands were gone. Currently, approximately seventy-five percent of the original tidal marsh and wetland areas in the Estuary has been filled or dredged, while the majority of what remains has been significantly altered.[12]

A detailed field survey of the shoreline conditions in the lower Passaic was conducted in 1994. Some of the results of the survey are shown in Table 1.[13] The "Point No Point Reach" is the lowest 1.3 miles of the River next to the Bay, and the survey results show that less than two percent of the shoreline in that area has any aquatic vegetation. The photograph in Figure 3 illustrates the typical bulkheaded shoreline, with no aquatic vegetation, that dominates the lower Passaic.[14] Table 2 summarizes highlights of the progression of industrial and urban impacts[15] while the ecological trends in the Estuary are summarized in Table 3.[16]

The historical losses of wetlands and habitat seriously reduce the ecological resources in the Bay and materially affect the determination of "prior conditions" as to subsequent releases. The following section illustrates how chemical contamination can also affect these determinations.

DAMAGES

Damages to natural resources can be assessed for physical, biological, and/or chemical injuries caused by the release. In remedial CERCLA actions, "injury" is expressed as the increased health and ecological risks caused by the release. In each case, these "injuries"

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[11] *See infra* fig.2.

[12] *See* D.F. Squires & J.S. Barclay, *Nearshore Wildlife Habitats and Populations in the New York/New Jersey Harbor Estuary*, 24 (Nov. 1990) (on file with the *Seton Hall Law Review*).

[13] *See infra* tbl.1.

[14] *See infra* fig.3.

[15] *See* Crawford, *supra* note 2, at 278; *infra* tbl.2.

[16] *See* Crawford, *supra* note 2, at 281; *infra* tbl.3.

are determined by technical interpretation of site data, as illustrated below.

Elevated levels of numerous chemicals, including PCBs, dioxins, PAHs, and metals are present in the Newark Bay Estuary. In addition to these chemicals, other contaminants, including pesticides, herbicides, and fertilizers, have entered the waters and sediments. Higher concentrations of most chemicals were detected in buried sediments dating back decades, while lower concentrations of contaminants were found in surface sediments. This finding is logically consistent with the historical industrial pattern of the Estuary, from the rapid industrial development that followed World War II to the emphasis on improved environmental management since the 1970s.[17] Recent water quality sampling at Passaic River outfalls, however, showed that chemical concentrations for arsenic, copper, lead, mercury, PCBs, and 2,3,7,8-TCDD (dioxin) exceeded promulgated water quality criteria.[18] These sampling results are consistent with the New York-New Jersey Harbor Estuary Program (HEP) findings that identified Combined Sewer Overflows (CSO) and storm water outfalls as significant sources of chemicals in the Estuary. The HEP attributed the majority of the incoming load for most metals and twenty-five percent of the load for PCBs to these outfalls.[19] Furthermore, a recent study that analyzed PCB concentrations in the influent[20] to twelve water pollution control plants that discharge into the Estuary indicated higher concentrations of PCBs than the Passaic River outfall results summarized in Table 4.[21]

Analysis of sediment quality samples taken in the Estuary disclosed similar chemicals in the sediment, but also indicated concentrations of PAHs, as shown in Table 5.[22] These chemicals arrived in the Estuary through historical and current discharges by direct spills, industrial outfalls, CSO and storm water outfalls, runoff, and atmospheric deposits.

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[17] *See* Crawford, *supra* note 2, at 278; *infra* tbl.2.

[18] *See infra* tbl.4.

[19] *See* N.Y.-N.J. HARBOR ESTUARY PROGRAM, FINAL COMPREHENSIVE CONSERVATION AND MANAGEMENT PLAN (Mar. 1996).

[20] The concentration of a contaminant in influent approximates the concentration that will be discharged by the Combined Sewer Overflows (CSOs).

[21] *See infra* tbl.4; *see also* Gregory S. Durell & Robert D. Lizotte, Jr., *PCB Levels at 26 New York City and New Jersey WPCPs That Discharge to the New York/New Jersey Harbor Estuary*, 32 ENVTL. SCI. & TECH. 1022 (1998).

[22] *See infra* tbl.5.

SOURCES OF CHEMICALS AND CAUSATION

There are a variety of sources of discharge into the Estuary. The sources of the chemicals described above are typically private or public facilities, mobile sources such as operating vehicles (engine exhaust), or vessels or rolling stock that spill or emit chemicals (boats, trucks, trains, etc.). Some sources discharged pollutants in the past; some are currently discharging pollutants. Furthermore, some source entities are now defunct, while others are currently viable.

Numerous sources of these chemicals, including some that continue to operate and discharge today, have been identified around the Newark Bay Estuary. These sources are located throughout the Estuary area in proximity to the shorelines. Their current discharges and emissions primarily reach the Estuary waters through CSO and storm water outfalls, and atmospheric deposits. Recent outfall sampling and analysis of seven currently operating outfalls along the lower Passaic River reported concentration levels of the same chemicals, including 2,3,7,8-TCDD, which exceeded promulgated surface water quality standards.[23]

Figure 4 indicates the locations of the various known outfalls into the lower Passaic River.[24] Many of these outfalls are the pathways for current discharges. The EPA has identified to date sixty-four facilities, representing approximately ninety companies, as shown in Figure 5, for investigation as potential sources of chemical discharges to the lower Passaic River.[25] So far, the EPA has notified thirteen companies as Potentially Responsible Parties (PRPs) for chemical releases into this part of the River, representing fourteen of the identified facilities.

As a result of finding the presence of various chemicals throughout the Estuary, the Project Team developed additional information to identify the locations of facilities in proximity to the Estuary that could be possible sources, historical or current, of chemical discharges to the Estuary. The identified locations are shown in Figures 6-8 for two metals and dioxins.[26]

The locations of about 500 facilities that might have contributed lead and 300 facilities that might have contributed mercury to the Estuary are shown in Figures 6 and 7.[27] These locations have been

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[23] *See infra* tbl.4.
[24] *See infra* tbl.4.
[25] *See infra* fig.5.
[26] *See infra* figs.6-8.
[27] *See infra* figs.6-7.

determined through a review of public information that identifies users, producers, and dischargers of the metals. As these figures indicate, many such facilities are located around the Estuary.

The locations of about 300 facilities that might have contributed dioxins, including 2,3,7,8-TCDD, to the Estuary are shown in Figure 8.[28] These locations have been determined on the basis of the type of industrial process activities that were, or are, conducted at the locations. Dioxins are generated as byproducts of numerous combustion and chemical processes. Specific processes that are known to produce dioxins, including 2,3,7,8-TCDD, are often grouped in the following manner:

- Combustion and Incineration Sources, including municipal, medical, and hazardous waste incinerators.
- Industrial Processes, including pulp and paper producers, wood treatment facilities, chlorophenoxy and chlorophenol producers and users, and PCB producers and users.
- Metallurgical Processes, including metal refining, smelting, forging, and recycling; coppersmiths; and cable and wire manufacturing.
- Power and Energy Generation Processes, including oil refining, coal combustion and gasification, and fuel consumption.

As Figure 8 indicates, many such facilities are located in proximity to the Estuary.[29]

The National Sediment Quality Survey (the Survey)[30] found a similar pattern of widespread occurrence of 2,3,7,8-TCDD in sediments located in industrial areas nationwide. The Survey classified 250 river-reaches nationwide as "Tier 1" for presence of dioxin where associated adverse effects are probable. The presence of dioxin is not unique to the Newark Bay Estuary but is a common occurrence in industrialized waterways.

Considering only the three chemicals noted above (lead, mercury, and dioxin), the very large number and distribution of their sources indicate the complexity of evaluating causation attributable to the individual sources responsible for discharges. Many other chemicals, such as PCBs, PAHs, pesticides, and herbicides, will significantly extend the requisite inquiry.

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[28] *See infra* fig.8.

[29] *See infra* fig.8.

[30] EPA, THE INCIDENCE AND SEVERITY OF SEDIMENT CONTAMINATION IN SURFACE WATERS OF THE UNITED STATES: NATIONAL SEDIMENT QUALITY SURVEY (1997).

The complexity of this matter is further illustrated by the substantial, numerous efforts underway to investigate and analyze the environmental conditions in the Estuary. Several public initiatives are underway. The New York/New Jersey Port Authority has reinvigorated its dredging program and consequent dredge spoils disposal efforts. The EPA is continuing to evaluate sediment disposal, treatment, and decontamination alternatives. Several scientific studies are underway to characterize further the water, sediment, and biota resources within the Estuary, generally under the direction of the EPA and the environmental authorities of New Jersey and New York. The CERCLA action in the lower Passaic River is a separate initiative in this matter.

A Comprehensive Conservation and Management Plan to coordinate the various activities underway is needed and has been proposed by the HEP for consideration by the States and other stakeholders. The primary recommendation of the National Sediment Quality Survey was to encourage additional investigation and assessment of contaminated sediment.[51] Furthermore, the survey endorsed the concept of addressing these issues on a watershed management scale and specifically recognized the New York-New Jersey Harbor Estuary Program as an example of implementing this approach.

CONCLUSIONS

Contaminated surface water and sediments in the Newark Bay Estuary should be addressed as a public works project, with Estuary-wide coordination and participation. The current water and sediment qualities in the Estuary are substantially improved over much earlier conditions, due to improving environmental care and protection. However, a comprehensive understanding of the environmental conditions throughout this large Estuary requires an Estuary-wide scientific analysis of sources and distribution of chemicals.

Relying on CERCLA remediation or any natural resource damage program to address remediation and restoration actions would be ineffective, very slow, and unlikely to lead to a solution for the Estuary. This is due primarily to the multitude of current and historical sources and chemicals involved that would likely confound determinations of baseline/background conditions, injuries and damages for particular releases, and potential individual liabilities for causation.

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[51] *See id.*

In order to obtain effective results with a reasonable use of resources, the contaminated surface water and sediments in the Estuary need to be administered under public works programs. The EPA endorses the idea of addressing these issues on a watershed management scale and specifically commends the HEP in the National Sediment Survey. This approach could involve the governmental agencies, area support groups, and the public and private sectors working together to achieve speedier results and a more efficient use of resources than the present separated approach.

APPENDIX A

N.L. Bonnevie et al., *Distribution of Inorganic Compounds in Sediments From Three Waterways in Northern New Jersey*, 51 BULL. ENVTL. CONTAMINATION AND TOXICOLOGY 627 (1993).

N.L. Bonnevie et al., *Lead Contamination in Surficial Sediments from Newark Bay, New Jersey*, 18 ENVTL. INT'L 497 (1992).

N.L. Bonnevie et al., *Trace Metal Contamination in Surficial Sediments from Newark Bay, New Jersey*, 144 SCI. TOTAL ENV'T 1 (1994).

D.W. Crawford et al., *Historical Changes in the Ecological Health of the Newark Bay Estuary, New Jersey*, 29 ECOTOXICOLOGY AND ENVTL. SAFETY 276 (1994).

D.W. Crawford et al., *Sources of Pollution and Sediment Contamination in Newark Bay, New Jersey*, 30 ECOTOXICOLOGY AND ENVTL. SAFETY 85 (1995).

C.A. Gillis et al., *Mercury Contamination in the Newark Bay Estuary*, 25 ECOTOXICOLOGY AND ENVTL. SAFETY 214 (1993).

C.A. Gillis et al., *p.p'-DDD, -DDE, and -DDT Contamination of Sediment in Newark Bay, New Jersey and its Major Tributaries*, 28 ARCHIVES ENVTL. CONTAMINATION AND TOXICOLOGY 85 (1995).

D.G. Gunster et al., *Assessment of Chemical Loadings to Newark Bay, New Jersey From Petroleum and Hazardous Chemical Accidents Occurring from 1986-1991*, 25 ECOTOXICOLOGY AND ENVTL. SAFETY 202 (1993).

D.G. Gunster et al., *Petroleum and Hazardous Chemical Spills in Newark Bay, New Jersey From 1982 to 1991*, 82 ENVTL. POLLUTION 245 (1993).

S.L. Huntley et al., *Combined Sewer Overflows (CSOs) as Sources of Sediment Contamination in the Lower Passaic River, New Jersey; Polychlorinated Dibenzo-P-Dioxins, Polychlorinated Dibenzofurans, and Polychlorinated Biphenyls*, 34 (2) CHEMOSPHERE 233 (1997).

S.L Huntley et al., *Distribution of Polycyclic Aromatic Hydrocarbons (PAHS) in Three Northern New Jersey Waterways*, 51 BULL. ENVTL. CONTAMINATION AND TOXICOLOGY 865 (1993).

S.L. Huntley et al., *Geochronology and Sedimentology of the Lower Passaic River, New Jersey*, 18 (2) ESTUARIES 351 (1995).

S.L. Huntley et al., *Identification of Historical PCDD/F Sources in Newark Bay Estuary Subsurface Sediments Using Polytopic Vector Analysis and Radiosotope Dating Techniques*, 36 (6) CHEMOSPHERE 1167 (1998).

S.L. Huntley et al., *Polycyclic Aromatic Hydrocarbon and Petroleum Hydrocarbon Contamination in Sediment from Newark Bay and its Tributar-*

ies, 28 ARCHIVES ENVTL. CONTAMINATION AND TOXICOLOGY 93 (1995).

T.J. Iannuzzi et al., *Combined Sewer Overflows (CSOs) as Sources of Sediment Contamination in the Lower Passaic River, New Jersey; Priority Pollutants and Inorganic Chemicals*, 34 (2) CHEMOSPHERE 213 (1997).

T.J. Iannuzzi et al., *Distribution and Possible Sources of Polychlorinated Biphenyls in Dated Sediment from the Newark Bay Estuary*, 28 ARCHIVES ENVTL. CONTAMINATION AND TOXICOLOGY 108 (1995).

N. M. Shear et al., *Evaluation of the Factors Relating Combined Sewer Overflows with Sediment Contamination of the Passaic River*, 32 (3) MARINE POLLUTION BULL. 288 (1996).

W. J. Walker & S.L. Huntley, *A Literature Review of Formation and Release of PCDD/Fs from Gas Manufacturing: A Previously Unidentified Source?*, 35 (7) CHEMOSPHERE 1409 (1997).

R. J. Wenning et al., *Accumulation of Metals, Polychlorinated Biphenyls, and Polycyclic Aromatic Hydrocarbons in Sediment From the Lower Passaic River, New Jersey*, 27, ARCHIVES ENVTL. CONTAMINATION AND TOXICOLOGY 64, (1994).

R. J. Wenning et al., *Accumulation of Metals, Polychlorinated Biphenyls, and Polycyclic Aromatic Hydrocarbons in Sediment From the Lower Passaic River, New Jersey*, 51 ARCHIVES ENVTL. CONTAMINATION AND TOXICOLOGY 865 (1993).

R. J. Wenning et al., *Chemometric Analysis of Potential Sources of Polychlorinated Dibenzo-P-Dioxins and Dibenzofurans in Surficial Sediments from Newark Bay, New Jersey*, 27(1-3) CHEMOSPHERE 55 (1993).

Figure 1. Map of Newark Bay Estuary

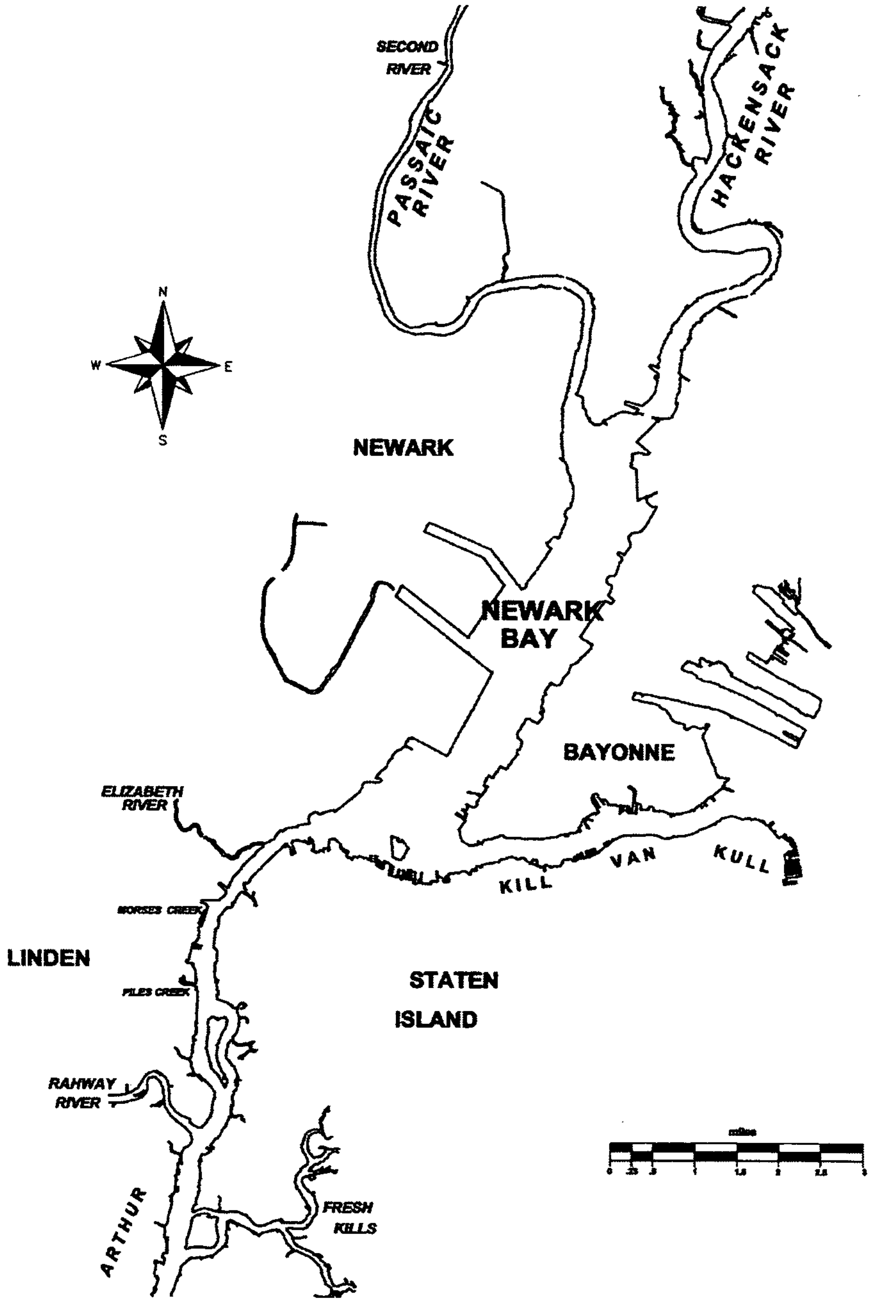


Figure 2. Man-Made Alterations to the Estuarine Habitats and Shoreline of the Lower Passaic River and Newark Bay, New Jersey, from 1900 to 1989.

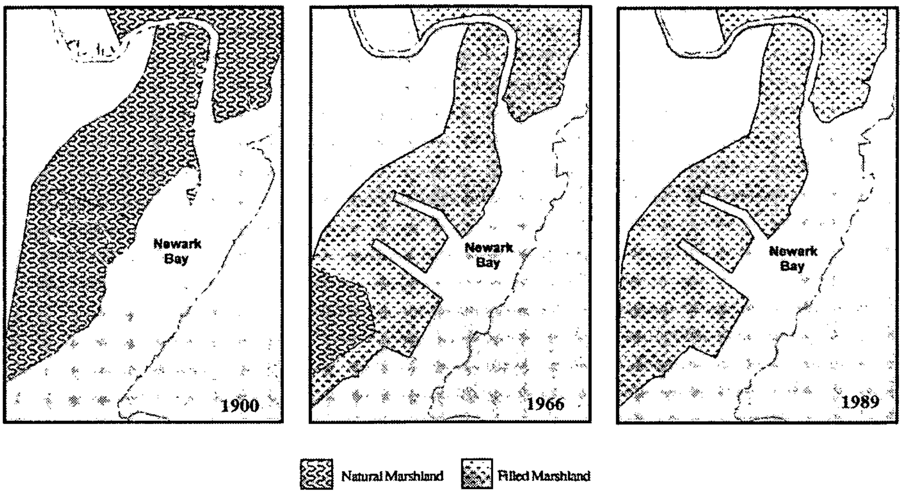


Figure 3. Typical Bulkhead Shoreline on the Passaic River.

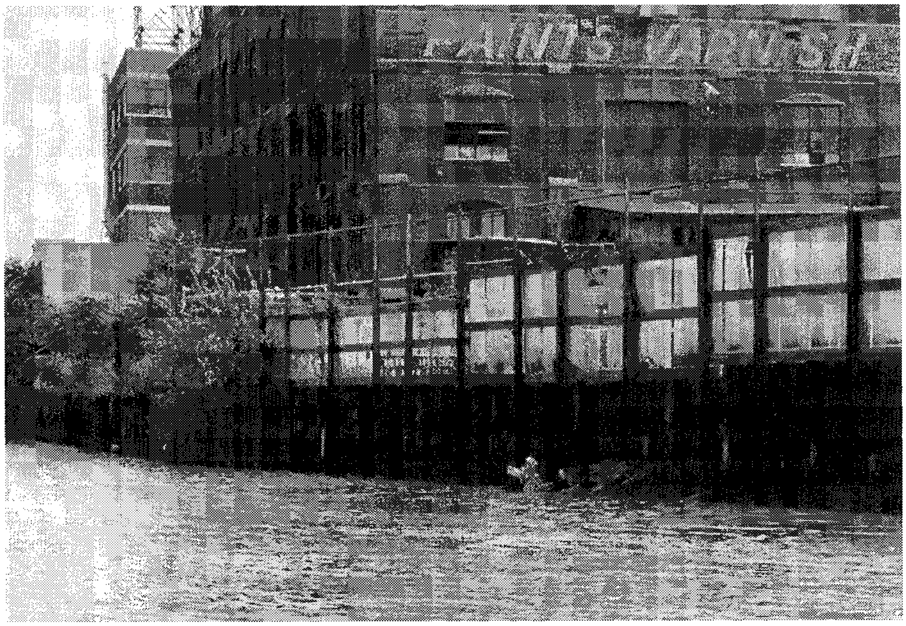


Figure 4. Locations of outfalls into the lower Passaic River.

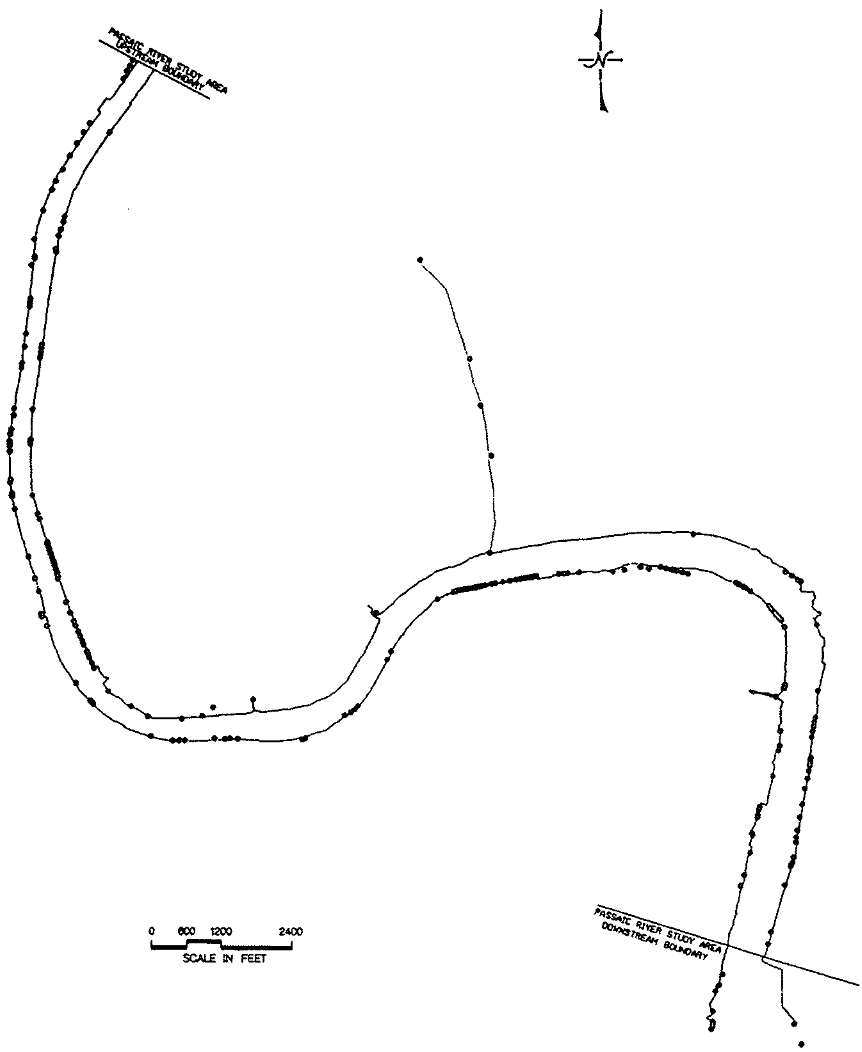


Figure 5. Facility Locations for Recipients of USEPA Superfund Information Request Letters.

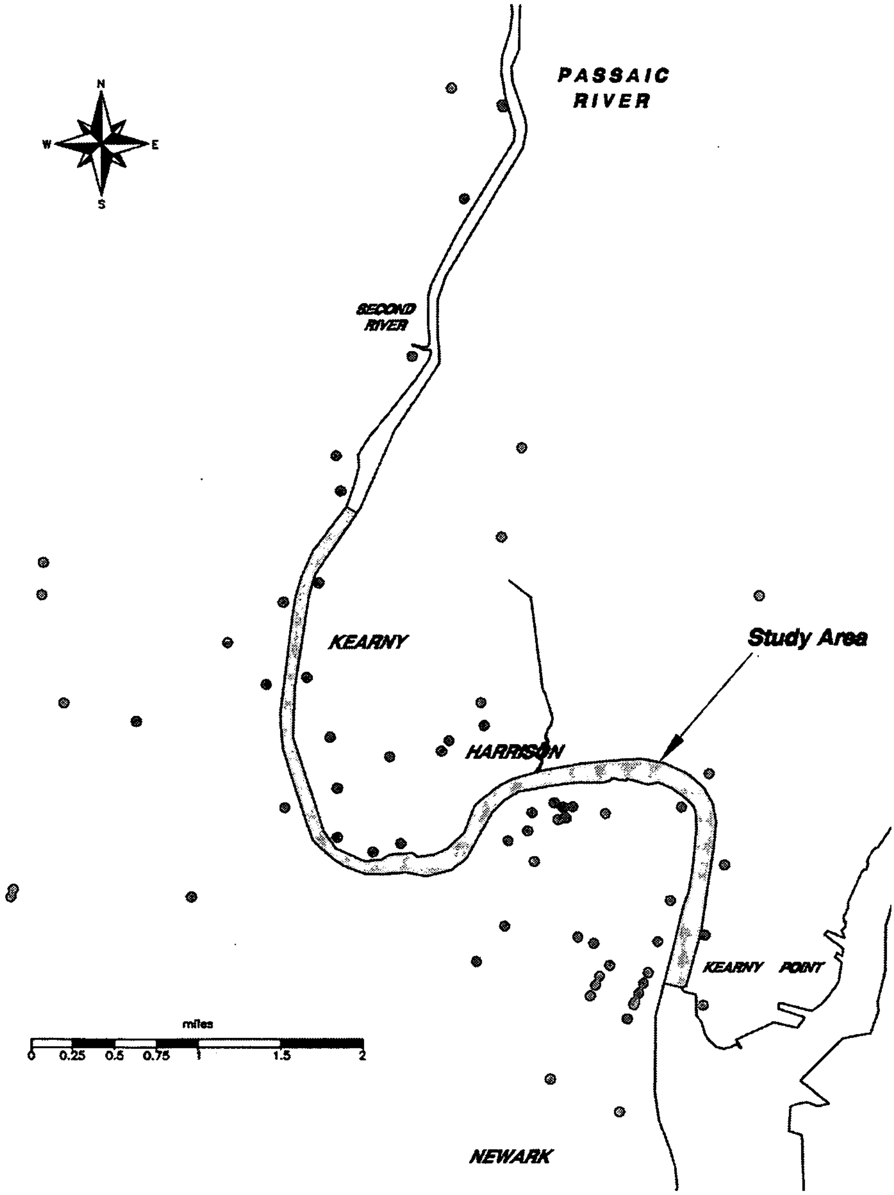
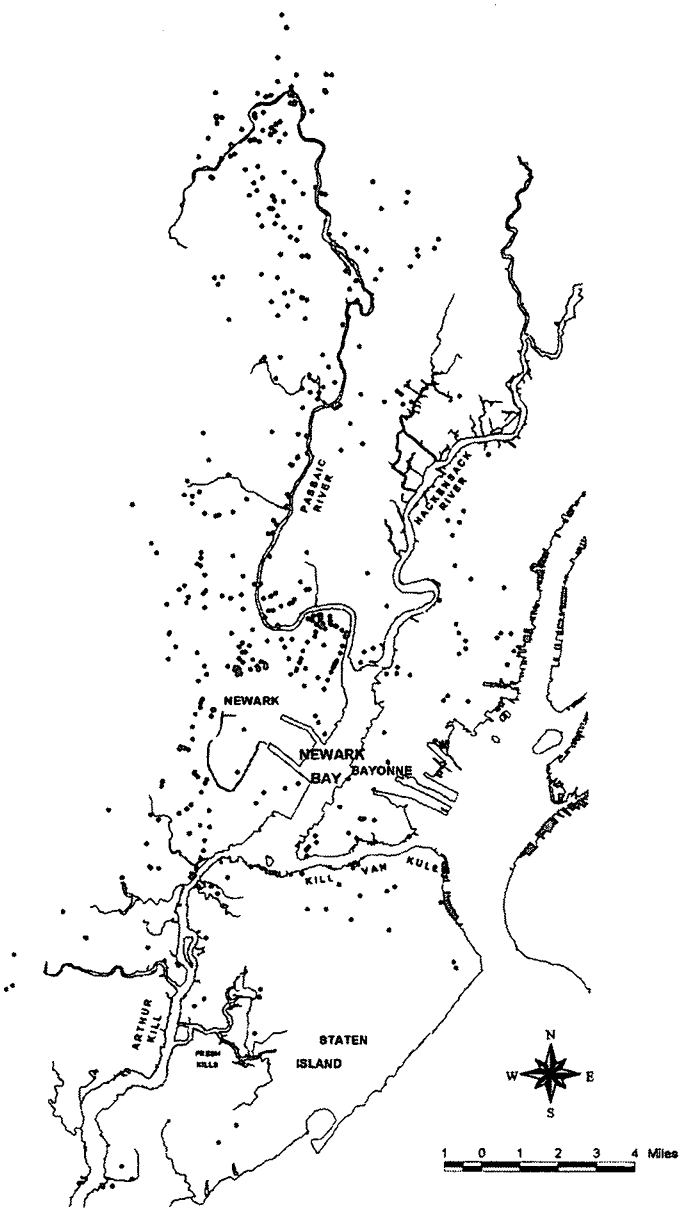
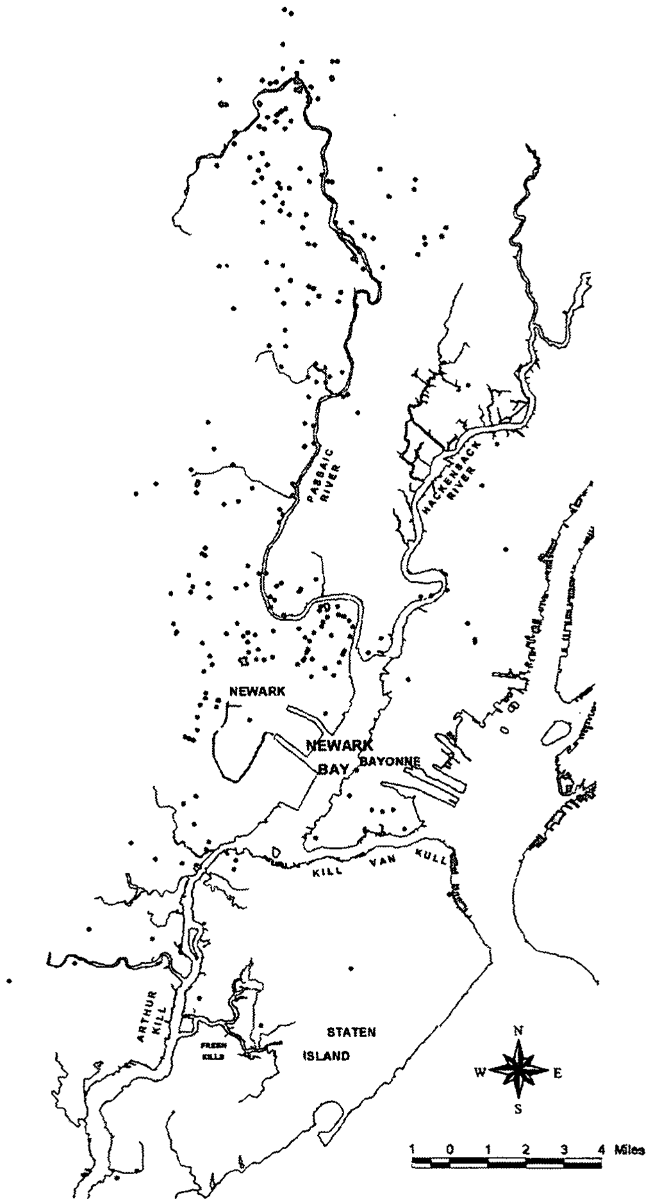


Figure 6. Possible Lead Sources to Newark Bay.



Information Derived From:
Elson T. Killam Associates, Inc. Heavy Metals Source Determination Study, Phase II, April 1980.
State of New Jersey, Department of Environmental Protection, Division of Water Quality, Bureau of Permit Management NJPDES Permittee Datebase.
The Right-to-Know Network. Permit control system (PCS) for Water Permits Database.
The Right-to-Know Network. RCRA Biennial Reporting System (BRS) for Hazardous Waste.

Figure 7. Possible Mercury Sources to Newark Bay.



Information Derived From:
Elson T. Killam Associates, Inc. Heavy Metals Source Determination Study, Phase II, April 1980.
State of New Jersey, Department of Environmental Protection, Division of Water Quality, Bureau of Permit Management NJPDES Permittee Datebase.
The Right-to-Know Network. Permit control system (PCS) for Water Permits Database.
The Right-to-Know Network. RCRA Biennial Reporting System (BRS) for Hazardous Waste.

Figure 8. Possible dioxin sources in Newark Bay estuary based on industrial activity.

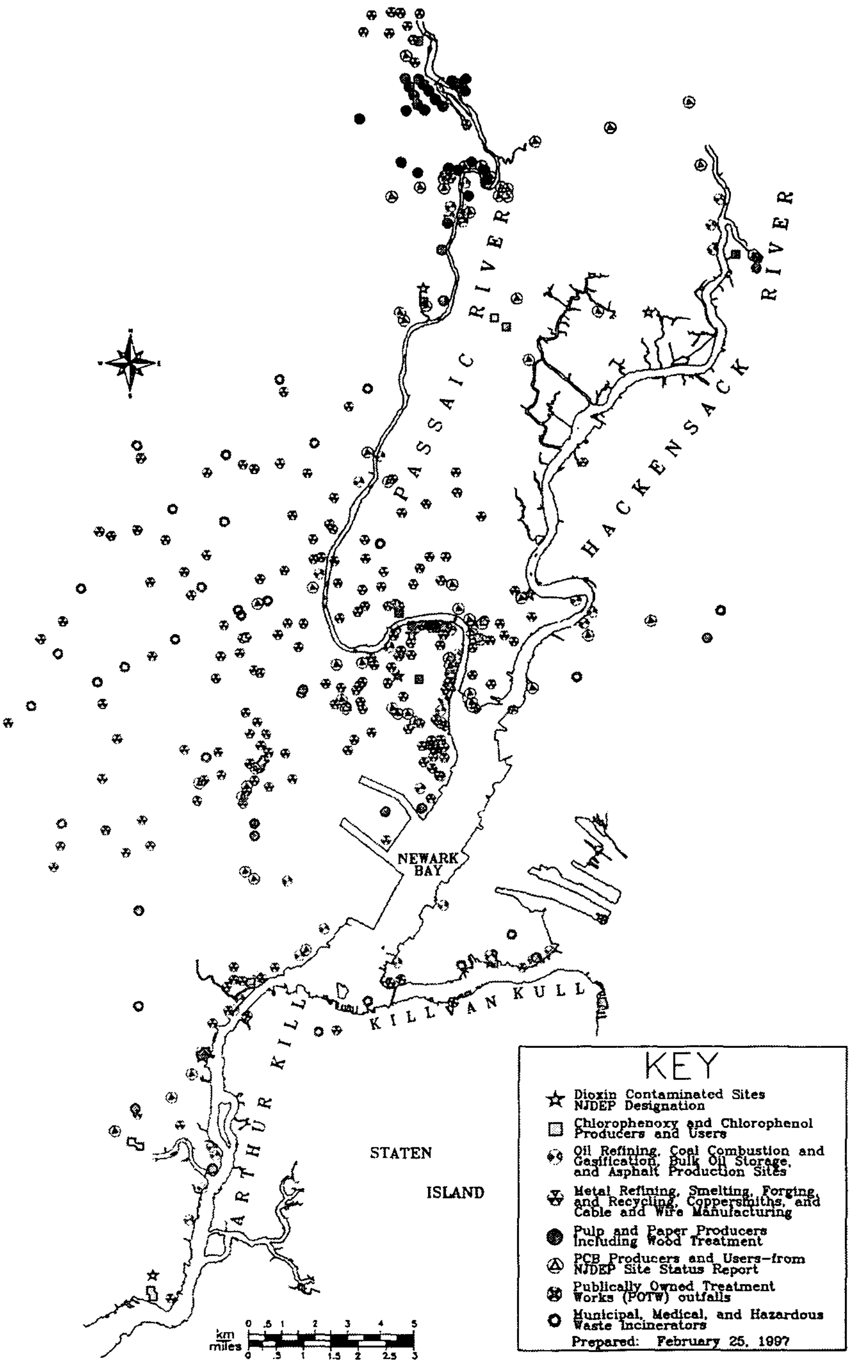


Table 1. Shoreline Features of the Lower Passaic River.

	Point No Point Reach				6-Mile Study Area	
	Left Bank		Right Bank		Total Shoreline	
	Approx. ft.	Percent of Total	Approx. ft.	Percent of Total	Approx. ft.	Percent of Total
Bulkhead	4,000	60%	4,500	67%	38,740	61%
Riprap	2,550	38%	1,500	22%	7,800	12%
Riprap/Vegetation	0	0	700	10%	10,380	16%
Aquatic Vegetation	150	2%	0	0	6,400	10%
Total Shoreline (ft.)	6,700		6,700		63,360	

Table 2. Highlights of Industrial and Urban Impacts to the Newark Bay Watershed

Year		Industry Classifications
1790-1800	Leather becomes a leading industry in Newark area	Leather, tanning
1830-1840	Paint and varnish manufacturing established Manufacturers begin experimenting with silk printing and dyestuffs	Pigments and paint Textiles and dyestuff
1850-1860	Newark becomes established in chemical industry First zinc oxide manufacturing facility founded (1852)	Chemicals Chemicals, paints
1870-1880	First electrolytic copper refinery opened (1881) First petroleum refineries built	Chemicals Petroleum
1880-1890	A major textile mill begins operations (1882) Major pharmaceutical company locates in the region	Textiles and dyestuff Pharmaceutical
1900-1920	Lead, pharmaceutical, paper, oil, paint and chemical operations expand 75% of all celluloid supplied by Newark-Arlington area World War I	Chemicals Pharmaceutical Pulp and paper Pigments and paint Plastics
1920-1930	Plastic industry boom (1926) New Jersey's refineries process almost 100 thousand barrels of oil per day Passaic Valley Sewer Trunk line completed (1924)	Plastics Petroleum
1930-1940	39 firms producing raw materials for plastics manufacturing (1939)	Chemicals, petroleum
1940-1950	First tetraflouroethylene resin produced 43 of a total of 56 tanneries in NJ located in Newark (1945) World War II	Plastics Chemicals, tanning
1950-1960	More than 130 paint and pigment manufacturers located in NJ (1954) 40% of NJ's textile plants located in Passaic County	Pigments and paints Textiles and dyestuff
1950-1979	PCB compounds used in wide range of chemical and manufacturing industries	

Table 3. Summary of Ecological Trends in the Newark Bay Watershed

Year		Reference
1880	Lower Passaic River considered prime freshwater fishing stream in New Jersey	Brydon, 1974
	Extensive shad fishing in Newark Bay, Passaic River and Hackensack River	Brydon, 1974
1885	Commission of Fisheries of NJ reports declining populations of shad due to pollution	Esser, 1982
1887	Reports of oil-tainted fish and shellfish	Earll, 1887
1900-1910	Shad catch (1908) reduced 84% from 1880 due to "off flavors"	Squires, 1981
1920-1930	Migratory bird communities damaged by oil slicks	Hurley, 1992
	U.S. War Department survey indicates that fish life is "destroyed"	Hurley, 1992
1960-1970	Bird populations beginning to increase	Brouwer, 1986 Parsons, 1993 Burger *et al.*, 1993
1970-1980	Ecological surveys indicate presence of 24 fish species in the Lower Passaic	Princeton, Aqua Science, 1982; McCormick and Koepp, 1978[a]
	Cormorants, herons, egrets, and ibisis begin to colonize breeding areas in the estuary	Brouwer, 1986 Parsons, 1993
	Surveys conducted indicating presence of pollution-tolerant species and reduced abundance	Princeton, Aqua Science, 1982; McCormick and Koepp, 1978[a]
1980-1990	Ecological surveys conducted indicating that conditions, although impacted, may be more favorable than previously reported	Cerrato, 1986

[a] Data reported in Cerrato, 1986.
Data from Crawford *et al.*, 1994.

Table 4. CSO and Stormwater Discharges to the Passaic River Exceeding National or New Jersey Water Quality Criteria 1997.

Analyte	Detection Frequency (%)	Exceedance Frequency (%)
Arsenic	64	64
Copper	82	82
Lead	45	45
Mercury	18	18
Phosphorus	100	100
Total PCBs	100	9
2378-TCDD	36	36

Table 5. Chemicals in Surface and Buried Sediments in the Passaic River Exceeding One or More Benchmark Sediment Quality Values. [1]

Metals	Semi-Volatile Organics	Pesticides	PCBs
Antimony	Acenaphthene	Aldrin	PCB-1242
Arsenic	Acenapthlyene	alpha-Chlordane	PCB-1248
Cadmium	Anthracene	gamma-Chlordane	PCB-1254
Chromium	Benzo(a)anthracene	Dieldren	PCB-1260
Copper	Benzo(a)pyrene	4,4'-DDE	Total PCBs
Lead	Benzo(g,h,i)perylene	4,4'-DDD	
Mercury	Bis(2-ethyl/hexyl)phthalate	4,4'-DDT	
Nickel	Chrysene	Total DDT	
Selenium	Dibenzo(a,h)anthracene		
Silver	Bibenzofuran		
Zinc	Fluoranthene		
	Fluorene		
	Indeno(1,2,3-c,d)pyrene		
	2-Methylnapaphthalene		
	Naphthalene		
	Phenanthrene		
	Pyrene		

[1] e.g., NOAA ERM, Long (1995).